Protected Species Mitigation and Monitoring Report

Cascadia Thrust Zone Structures in the Northeast Pacific Ocean

3 July 2012 - 6 July 2012

R/V Marcus G. Langseth

Prepared for

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1. EXECUTIVE SUMMARY

The National Science Foundation (NSF) owned research vessel (R/V), *Marcus G. Langseth*, operated by Lamont-Doherty Earth Observatory (L-DEO), a part of Columbia University, conducted a seismic survey of the Cascadia thrust zone in the Northeast Pacific Ocean. The purpose of the survey was to provide information on complex buried structures in this region that appear to affect the frictional behavior of the plate boundary megathrust fault. The *R/V Langseth* began this project immediately upon completion of survey line for the Juan de Fuca Plate Evolution and Hydration project, on 3 July 2012. The survey was completed on 6 July 2012 and the *Langseth* continued acquisition on survey lines for the Juan de Fuca Plate project once again.

L-DEO submitted an application to the National Marine Fisheries Service (NMFS) for a permit to harass marine mammals, incidental to the marine geophysical survey. An Incidental Harassment Authorization (IHA) was granted on 27 June 2012 (Appendix A) with several mitigation measures that stipulated harassment to marine mammals. Mitigation measures were implemented to minimize potential impacts to marine mammals throughout the duration of the survey. Mitigation measures included, but were not limited to, the use of NMFS approved protected species observers (PSOs) for both visual and acoustic monitoring, establishment of safety radii, and implementation of ramp-up, power-down and shut-down procedures.

RPS was contracted by L-DEO to provide continuous protected species observation coverage and to fulfill the environmental regulatory requirements and reporting mandated by NMFS in the IHA. Four PSOs and one dedicated passive acoustic monitoring (PAM) operator were present on board the *Langseth* throughout the survey in this capacity.

PSOs undertook a combination of visual and acoustic watches, conducting a total of 40 hours 43 minutes of visual observations and 54 hours 31 minutes of acoustic monitoring over the course of the survey.

This visual monitoring effort produced a project total of 19 protected species detection records; all for cetaceans. Of the 19 cetacean detections, 12 detections were of mysticetes and nine detections of unidentified whales. There were no acoustic detections using the PAM system.

Detections of protected species resulted in ten mitigation actions being implemented; eight power-downs and two shut-downs of the acoustic source. A known 35 cetaceans were observed to be exposed to received sound pressure levels equal to or greater than 160 dB from the acoustic source, constituting a level B harassment take as defined by NMFS. Cetacean Level B harassment takes included 23 humpback whale 'takes', 10 unidentified whale 'takes', and two unidentified baleen whale 'takes'. The IHA originally issued 12 'takes' for humpback whales and that number was exceeded on 5 July 2012. At this time the 160 dB safety radius was used for humpback whales, however by the end of the project on 6 July 2012 the 'takes' for humpback whales had been exceeded by 11 animals.

A project summary sheet of observation, detection, and operational totals can be found in Appendix B.

2. INTRODUCTION

The following report details protected species monitoring and mitigation as well as seismic survey operations undertaken as part of the Cascadia Thrust Zone Structures (Trehu) marine geophysical survey on board the *R/V Langseth* from 3 July to 6 July 2012 in the Northeast Pacific Ocean.

This document serves to meet the reporting requirements dictated in the IHA issued to L-DEO by NMFS on 27 June 2012. The IHA authorized non-lethal takes of Level B harassment of specific marine mammals incidental to a marine seismic survey program. NMFS has stated that seismic source received sound levels greater than 160 dB could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered as "takes" of these exposed animals. Potential consequences of Level B harassment taking could include effects such as temporary or permanent hearing threshold shifts, behavior modification and other reactions. It is unknown to what extent cetaceans exposed to seismic noise of this level would express these effects, and in order to take a precautionary approach, NMFS requires that provisions such as safety radii, power-downs and shut-downs be implemented to mitigate for these potential impacts.

2.1. PROJECT OVERVIEW AND LOCATION

The survey was conducted in the northeastern Pacific Ocean, off the coast of Oregon. The survey took place in the approximate area of 43 to 45° North and 124 to 125° West, where water depths ranged from ~50 m to 1000 m (Figure 1). The *Langseth* deployed an array of 36 airguns as an energy source. The receiving system consisted of ocean bottom seismometers (OBSs). As the airgun array was towed along the survey lines the OBSs record the returning acoustic signals internally for later analysis.

A total of approximately 265.35 km of transect lines were surveyed. The *Langseth*'s cruising speed was about 10-12 knots during transits and varied between 4 and 5 knots during the seismic survey. Seismic acquisition began on 3 July 2012 and continued until 6 July 2012.

This study will result in a 3-D image of the seismic velocity structure of the Cascadia thrust zone, which will provide information on complex buried structures in this region that appear to affect the frictional behavior of the plate boundary megathrust fault. A better image of the structure in this region, which coincides with apparent north-south changes in the frequency of occurrence of very large earthquakes and in contemporary patterns of strain accumulation, will provide background information for generating improved earthquake hazards analyses and a better understanding of the processes that control megathrust earthquake characteristics.

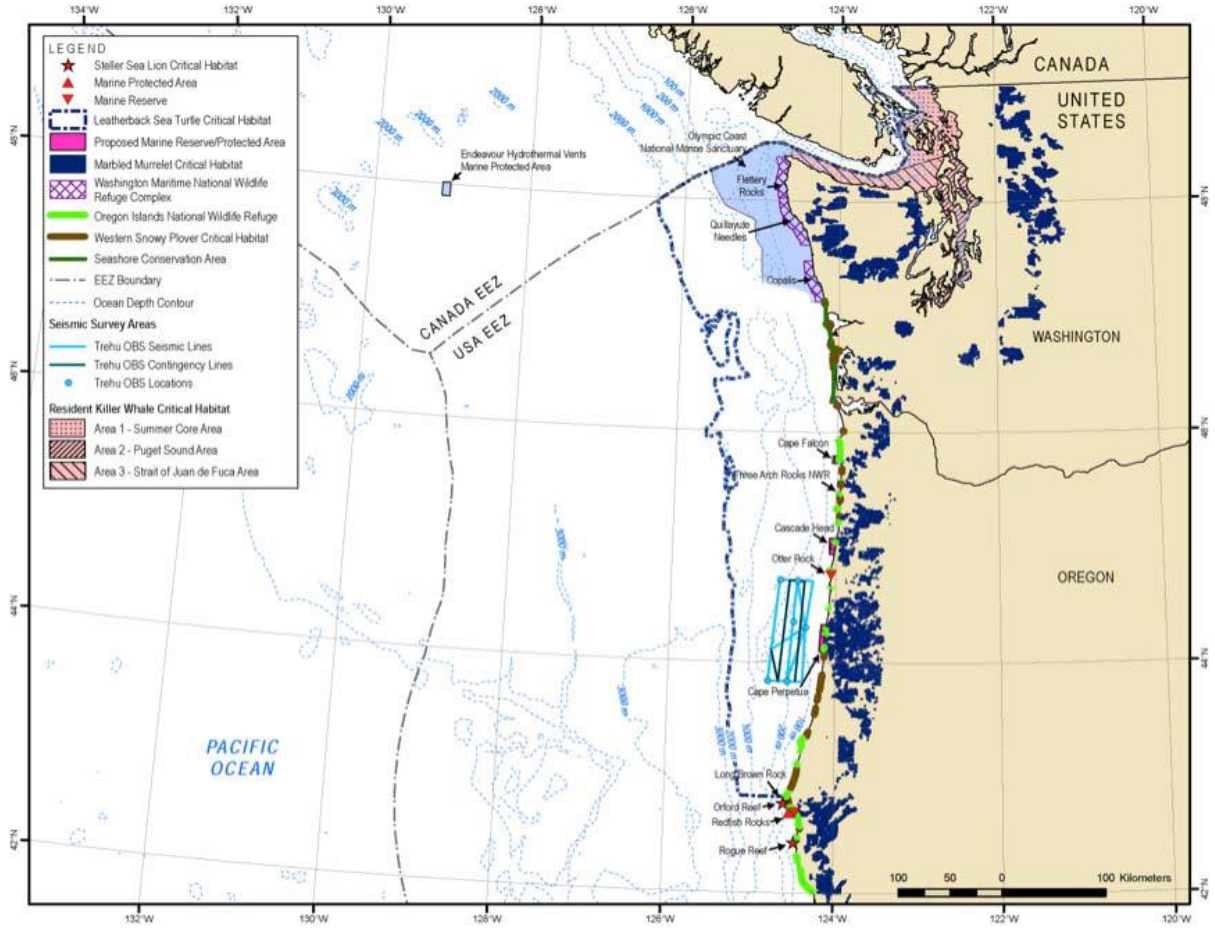

Figure 1. Location of the Cascadia thrust zone (Trehu) marine geophysical survey in the Northeastern Pacific Ocean.

2.1.1. Energy Source

The acoustic source consisted of four towed airgun sub-arrays and one hydrophone streamer cable. The sub-arrays were deployed centrally astern as a single acoustic source with each array separated by eight meters. The airguns were towed at a depth of 12 meters for OBS survey lines, were situated 232 meters from the Navigational Reference Point (NRP), which was located on the PSO observation tower.

Each source array utilized a mixture of Bolt 1500LL and Bolt 1900LLX airguns ranging in volume from the smallest airgun of 40 in³ to 360 in³. Each sub-array contained ten airguns, with the first and last spaced 16 meters apart. Only nine airguns on each sub-array were firing during survey acquisition, with the tenth gun utilized as a spare. The total volume of each sub-array was 1,650 in³. The full power source of four sub-arrays (36 airguns) had a total discharge volume of 6,600 in³ and a pressure of 1,900 psi. Each discharge of the source consisted of a single brief pulse of sound (duration of approximately 0.1 second) with the greatest energy output occurring in the two to 188 hertz frequency range.

The shot point interval for the OBS survey was 37.5 meters, equating to approximately 16 seconds at typical survey speed.

In addition to the operations of the airgun array, a Kongsberg EM 122 multibeam echosounder (MBES), a Knudsen Chirp 3260 sub-bottom profiler (SBP), and a hull-mounted acoustic Doppler current profiler (ADCP) was operated from the *Langseth* continuously throughout the cruise. These sound sources are operated from the *Langseth* simultaneous with the airgun array.

For the Cascadia thrust zone study, six OBSs were deployed at each of the southern and northern survey areas and retrieved after the lines were shot. WHOI "D2" OBSs were used during the cruise. This type of OBS has a height of ~1 m and a maximum diameter of 50 cm. The anchor is made of hot-rolled steel and weighs 23 kg. The anchor dimensions are 2.5×30.5×38.1 cm. Once an OBS was ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9–11 kHz, and a response is received at a frequency of 9–13 kHz. The burn-wire release assembly was then activated, and the instrument was released from the anchor to float to the surface. OBS deployment and retrieval was carried out by the R/V *Oceanus*.

3. MITIGATION AND MONITORING METHODS

The PSO monitoring program on the *Langseth* was established to meet the IHA requirements that were issued to the L-DEO by NMFS, which included both monitoring and mitigation objectives. The survey mitigation program is designed to minimize potential impacts of the *Langseth*'s seismic program on marine turtles, marine mammals, and other protected species of interest. The following monitoring protocols were followed to meet these objectives.

- Visual observations were established to provide real-time sighting data, allowing for the implementation of mitigation procedures as necessary.
- Operation of a PAM system to compliment visual observations and provide additional marine mammal detection data.
- Ascertain the effects of marine mammals and marine turtles exposed to sound levels constituting a "take".

In addition to the mitigation objectives outlined in the IHA, PSOs collected and analyzed necessary data mandated by the IHA for this report including but not limited to:

- Dates, times and locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and related activities during all seismic operations and marine mammal detections.
- Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity including the number of power-downs and shut-downs, were observed and logged throughout all monitoring actions.
- An estimate of the number, decided by species, of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 µPa (rms), 180 dB re 1 µPa (rms) and/or 190 dB re 1 µPa (rms) along with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 µPa (rms), 180 dB re 1 µPa (rms) and/or 190 dB re 1 µPa (rms) along with a discussion of the plausible consequences of that exposure on the individuals that were within the safety radii.
- A description of the implementation and effectiveness of the: (A) terms and conditions of the ITS and (B) mitigation measures of the IHA.

3.1. VISUAL MONITORING SURVEY METHODOLOGY

There were five trained and experienced PSOs on board to conduct the monitoring for marine mammals, record and report on observations, and request mitigation actions in accordance to the IHA. The PSOs on board were NMFS approved and held certifications from a recognized Joint Nature Conservation Committee (JNCC) course and/or approved Bureau of Ocean Energy Management (BOEM) course. Visual monitoring was primarily carried out from an observation tower (Figure 2) located 18.9 meters above the water surface which afforded the PSOs a 360 degree viewpoint around the acoustic source.

Figure 2. Protected Species Observer observation tower with mounted big-eye binoculars.

The PSO tower was equipped with Fujinon 7x50 binoculars as well as two mounted 25x150 Big-eye binoculars. Inside the tent located in the middle of the platform was a laptop for data collection as well as a telephone for communication with the PAM station, bridge, or main lab. Also inside the tent was a monitor that displayed current information about the vessel's position, speed, and heading, along with water depth, wind speed and direction, and source activity. Most observations were held from the tower; however, when there was severe weather or poor environmental conditions observations would be performed from the bridge (~12.8m above sea level) or the catwalk (~12.3m above sea level) in front of the bridge. Night Quest NQ2200 Night Vision Devices were also available to conduct night time observations for nighttime ramp-ups of the acoustic source, but were not used during this survey.

Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHA. At least one PSO, but most often two PSOs, watched for marine mammals and sea turtles at all times while airguns operated during daylight periods and whenever the vessel was underway when the airguns were not firing.

When the acoustic source was activated from silence, PSOs maintained a two-person watch for 30 minutes prior to the activation of the source. Visual watches commenced each day before sunrise, beginning as soon as the safety radii were visible, and continued past sunset until the safety radii became obscured. Start of observation times ranged from 5:51 to 6:07 local time, while end of observation times ranged from 21:55 to 22:05 local time.

A visual monitoring schedule was established by the PSOs where each person completed visual observations watches which varied in length between two to four hours, two to three times a day, for a total of four to eight hours of visual monitoring per day. This schedule was arranged to ensure that two PSOs were on visual observation duty at all times except during meal breaks when PSOs would each maintain a solo watch so that the entire team could eat while maintaining both visual and acoustic monitoring. Solo watches lasted less than 45 minutes and occurred each day at meal times.

Observations were focused forward of the vessel and to the sides but with regular sweeps through the area around the active acoustic source. PSOs searched for blows indicating the presence of a marine mammal, splashes or disturbances to the sea surface, the presence of large flocks of feeding seabirds and other sighting cues indicating the possible presence of a protected species.

Upon the visual detection of a protected species, PSOs would first identify the animals range to the acoustic source while identifying the observed animal (cetacean, pinniped, or sea turtle) to determine which safety radius applied to the animal. The visual PSOs would then notify the PAM operator, who was located in the main science lab, that there was an animal inside or outside of the safety radius. If the animal was observed inside the safety radius and a mitigation action was necessary, the PAM operator would relay the message to the seismic technician who sits nearby. Table 1 describes the various exclusion zone radii applied to cetaceans and pinnipeds, as well as what constituted the Level-B harassment zone. The PAM operator was also notified of all marine mammal sightings as soon as possible in order to enable recordings to be made for possible analysis later by one of the more experienced acoustic operators to determine whether vocalizations had been detected on the PAM system during the sighting.

Table 1. Safety radii (SR) for triggering mitigation.

Source and Volume	Array Tow Depth (m)	Water Depth (m)	Power/Shut-down SR for Pinnipeds 190 dB (m)	Power/Shut-down SR for Cetaceans 180 dB (m)	Level-B Harassment Zone 160 dB (m)
Single bolt airgun (40 in³)	6 to 15	Shallow (<100)	150	296	1,050
		Intermediate (100-1,000)	18	60	578
		Deep (>1,000)	12	40	385
4 strings 36 airguns (6,600 in³)	12	Shallow (<100)	770	2,250	23,470
		Intermediate (100-1,000)	615	1,810	13,935
		Deep (>1,000)	460	1,100	4,400

When a protected species was observed, range estimations were made using reticle binoculars, the naked eye, and by relating the animal to an object at a known distance, such as the acoustic array located 232 meters from the PSO tower. Specific species identifications were made whenever distance, length of sighting and visual observation conditions allowed. PSOs observed anatomical features of animals sighted with the naked eye and through the big-eyes and reticule binoculars and noted behavior of the animal or group. Photographs were taken during most sightings. Sometimes photographs were not taken due to the brevity of a sighting. The camera used was a Canon EOS 60D with a 300 millimeter telephoto lens. Marine mammal

identification manuals were consulted and photos were examined during visual watch breaks to confirm identifications.

During or immediately after each sighting event PSOs recorded the position, time at first and last sighting, number of animals present (adults and juveniles), the initial and any subsequent behaviors observed, the initial range, bearing and movement of the animal(s), the source activity at the initial and final detections and any mitigation measures that were applied. Specific information regarding the animal(s) closest approach to the vessel, acoustic source and the acoustic source output at the closest approach were recorded to determine if the animals had been exposed to 160 dB and/or 180/190 dB of sound from the source during the sighting event. Additionally, the vessel position, water depth, vessel heading and speed, the wind speed and direction, Beaufort sea state, swell level, visibility and glare were recorded every half an hour at minimum or every time environmental conditions, vessel, or seismic activity changed. Each sighting event was linked to an entry on a datasheet such that environmental conditions were available for each sighting event.

3.2. ACOUSTIC MONITORING SURVEY METHODOLOGY

PAM was used to augment visual monitoring efforts, by helping to detect, identify, and locate marine mammals within the area. PAM was also used during periods of darkness or low visibility when visual monitoring might not be applicable or effective. The PAM system was monitored to the maximum extent possible, 24-hours a day during seismic operations, and the times when monitoring was possible while the airguns were not in operation. PAM was not used exclusively to execute any mitigation actions without a concurrent visual sighting of the marine mammal, with the exception of acoustic detections of killer whales (*Orcinus orca*) where the acoustic source was to be shut-down until 30 minutes after the last acoustic detection. No killer whales were acoustically detected during this survey.

Two PSOs who were trained and experienced with the use of PAM, were present throughout the cruise. One person was designated as the PAM operator to oversee and conduct the PAM operations. All PSOs completed a PAM training provided by the PAM operator in the initial days of the hydrophone deployment during which basic PAM system operation was covered. To achieve 24-hours of monitoring, the PSOs and the PAM operator rotated through acoustic monitoring shifts with the PAM operator monitoring many of the night time hours when PSOs were not making visual observations and the PAM was the only system in use for detecting cetaceans. Acoustic monitoring shifts lasted one to six hours. During daylight hours, acoustic operators were in communication with visual PSOs in the tower relaying sighting and seismic activity information. The PAM system was located in the main science lab to provide adequate space for the system, allow a quick exchange of communications with the visual PSOs on watch and seismic technicians, and to provide access to the vessel's instrumentation. The vessel's position, water depth, heading and speed, vessel and airgun activity were recorded every hour.

Acoustic monitoring for marine mammals was conducted aurally with *Sennheiser* headphones and visually with *Pamguard Beta 1.10.00*. Delphinid whistles, clicks, and burst pulses as well as sperm whale and baleen whale vocalizations may be viewed on a spectrogram display within *Pamguard*. Sperm whale, beaked whale, *Kogia* species, and delphinid echolocation clicks may be viewed on low and high frequency click detector displays. The Spectrogram's amplitude range and appearance were adjusted as needed to suit the operator's preference to maximize the vocalizations appearance above the pictured background noise.

3.2.1. Passive Acoustic Monitoring Parameters

Acoustic monitoring was carried out using a PAM system developed by Seiche Measurements Limited. PAM system specifications can be found in Appendix C. The PAM system consists of seven main components: a 250m hydrophone tow cable, a 100m deck cable, a data processing unit, two laptops, an acoustic analysis software package, and headphones for aural monitoring.

The hydrophone cable contains four hydrophone elements and a depth gauge molded into a 5 meter section of the cable. Three of the hydrophone elements are broadband (2 to 200kHz) and the fourth element is for sampling lower frequencies (75Hz to 30kHz). Preamplifiers are also embedded into the array cable just ahead of each hydrophone element. The four-element linear hydrophone array permits a large range for sampling marine mammal vocalizations.

The electronic processing unit contained a buffer processing unit with USB output, an *RME Fireface 800 ADC* processing unit with firewire output, a *Behringer Ultralink Pro mixer*, a *Behringer Ultralink Pro graphic equalizer* and a Sennheiser radio headphone transmitter. Two laptops were set-up in the main lab next to the electronic processing unit to display a high frequency range on one laptop (hereafter referred to as the HF laptop), using the signal from two hydrophones, and the low frequency on the other laptop (LF laptop) receiving signal from all four hydrophones. A GPS feed of INGGA strings was supplied from the ship's navigation system and connected to the LF laptop, reading data every 20 seconds.

The high frequency (HF) system was used to detect and localize ultrasonic pulses used by some dolphins, beaked whales and *Kogia* species. The signal from two hydrophones was digitized using an analogue-digital National Instruments data acquisition (DAQ) soundcard at a sampling rate of 500 kilohertz, then processed and displayed on a laptop computer using the program *Pamguard Beta 1.10.00* via USB connection. The amplitude of clicks detected at the front hydrophone was measured at 5th order Butterworth band-pass filters ranging from 35 kilohertz to 120 kilohertz with a high pass digital pre-filter set at 35 kilohertz (Butterworth 2nd order). *Pamguard* can use the difference between the time that a sound signal arrived at each of the two hydrophones to calculate and display the bearing to the source of the sound. A scrolling bearing time display in *Pamguard* also can display the detected clicks within the HF envelope band pass filter in real time, which would allow the identification and directional mapping of detected animal click trains.

The low frequency (LF) system was used to detect sounds produced by marine mammals in the human audible band between approximately four kilohertz and 24 kilohertz. The low frequency system used four hydrophones; the signal was interfaced via a firewire cable to a laptop computer, where it was digitized at 48 kilohertz per channel. The LF hydrophone signal was further processed within the *Pamguard* monitoring software by applying Engine Noise Fast Fourier Transform (FFT) filters including click suppression and spectral noise removal filters (median filter, average subtraction, Gaussian kernel smoothing and thresholding). In addition to the Spectrogram available for each of the four hydrophones, modules for Click Detector, Mapping, Sound Recording and Radar displays for bearings of whistles and moans were configured. The bearings and distance to detected whistles and moans can be calculated using a Time-of-Arrival-Distance (TOAD) method (the signal time delay between the arrival of a signal on each hydrophone is compared), and presented on a radar display along with amplitude information for the detected signal as a proxy for range. The vessel's GPS connected to the LF laptop via serial USB and allowed delphinid whistles and other cetacean vocalizations to be

plotted onto a map module where bearing and range to the vocalizing animal's actual position could be obtained. A mixer unit enabled the operator to adjust stereo signal levels from each of the four hydrophones. The PAM Operator monitored the hydrophone signals aurally using headphones.

3.2.2. Hydrophone Deployment

The vessel had a winch installed on the port stern deckhead of the gun deck for deployment of the PAM hydrophone cable. Two deck cables, the main cable and a spare, were installed along the gun deck deckhead running from the winch to the science lab.

Figure 3 shows the position of the hydrophone deployments in relation to the vessel and seismic equipment. Photos of the hydrophone deployment methods and equipment discussed above can be found in Appendix D.

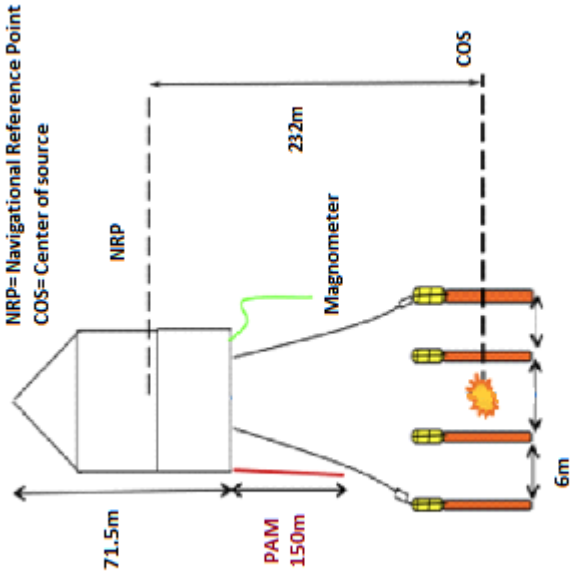

Figure 3. Location of the hydrophone deployment.

4. MONITORING EFFORT SUMMARY

4.1. SURVEY OPERATIONS SUMMARY

The *R/V Langseth* began acquisition on the Cascadia Thrust Zone immediately upon completion of survey lines for another project so the airguns were already firing at full power at the beginning of the survey. Acquisition of the first OBS survey line began at 21:04 UTC on 3 July 2012 and acquisition of the final survey line was completed at 2:36 UTC on 6 July. Upon completion of the final survey line the *R/V Langseth* returned to acquiring survey lines for the Juan de Fuca Plate project and the acoustic source remained active between lines. Table 2 outlines the dates and times of acquisition for each survey line.

Table 2. Cascadia thrust zone marine geophysical survey ocean bottom seismometer survey lines acquired.

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced	Date Acquisition Completed	Time Acquisition Completed
TREHUOBS01 Seq030	3-Jul-2012	21:04	3-Jul-2012	23:18
TREHUOBS02 Seq031	3-Jul-2012	23:19	4-Jul-2012	01:23
TREHUOBS03 Seq032	4-Jul-2012	01:39	4-Jul-2012	12:56
TREHUOBS04 Seq033	4-Jul-2012	13:14	4-Jul-2012	15:31
TREHUOBS05 Seq034	4-Jul-2012	15:34	5-Jul-2012	04:24
TREHUOBS06 Seq035	5-Jul-2012	04:35	5-Jul-2012	07:07
TREHUOBS07 Seq036	5-Jul-2012	07:08	5-Jul-2012	17:00
TREHUOBS08 Seq037	5-Jul-2012	18:56	5-Jul-2012	22:43
TREHUOBS09 Seq038	5-Jul-2012	22:44	6-Jul-2012	02:36

The acoustic source was active throughout the survey, with few periods of source silence, for a total of 53 hours 58 minutes of source activity. This includes ramp-up of the airguns, full power and partial power firing both online and during line changes, and operation of a single 40 in³ mitigation airgun (Figure 4). The mitigation source was to be used during mitigation power-downs initiated for protected species inside the safety radius as well as for mechanical/technical reasons and was active for 4 hours 41 minutes during the survey. Full power source operations, while online, accounted for 88% (47 hours 32 minutes) of airgun activity during the project. Also because the data was still usable while shooting at partial power (volume 4770 in³) a portion of survey line was shot using partial power while maintenance was performed on an array, accounting 9 minutes of array activity. Line changes were all shot at full or partial power, totalling 33 minutes of array activity. Additionally, the full volume of the acoustic source (36 airguns firing) was 6560 in³.

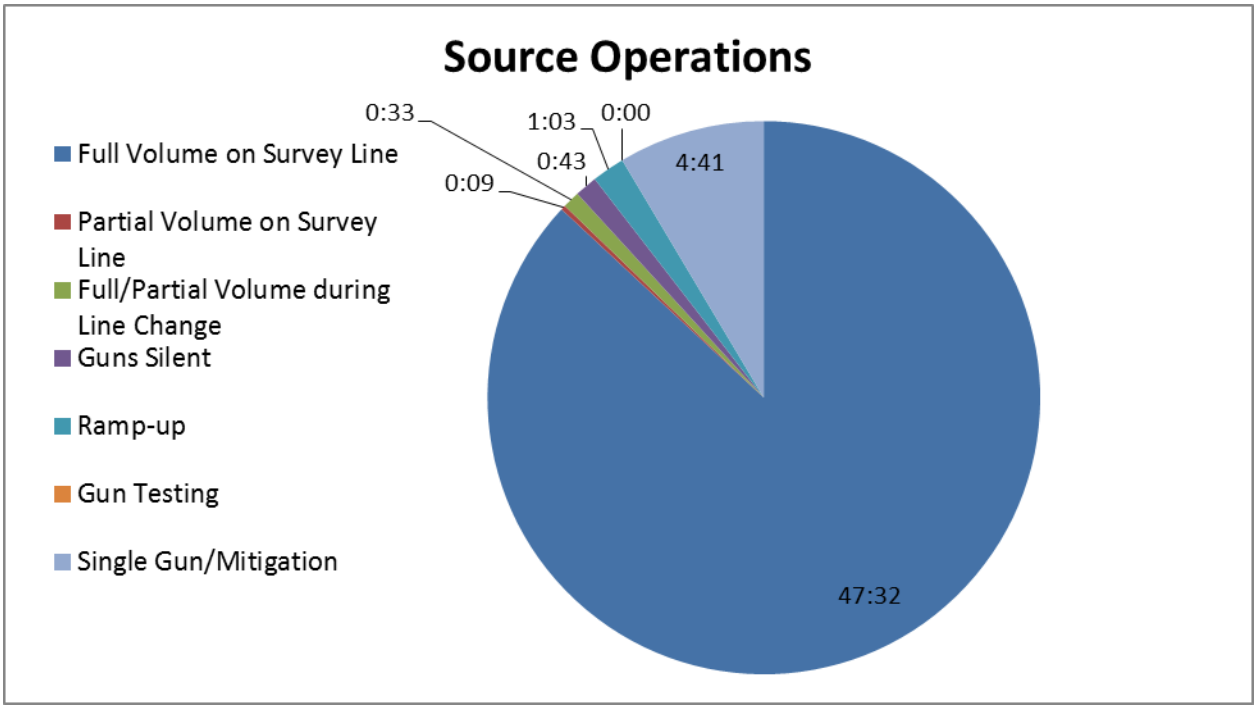

Figure 4. Total acoustic source operations.

The acoustic source was ramped up twice over the course of the survey in order to commence full power survey operations (Table 4). The first ramp up of the acoustic source was conducted from silence over the duration of 32 minutes. This ramp up was conducted to resume use of the acoustic source after a mitigation shut-down after PSOs mistakenly identified humpback whales as Northern right whales. The second ramp up was conducted from silence over the duration of 31 minutes. This ramp up was conducted to return to full power production after a mitigation shut-down of the acoustic source due to humpback whales being observed within the 160 dB safety radius, after their takes had been exceeded. The ramp ups were conducted using the NMFS approved automated gun controller program, DigiShot which adds guns sequentially to achieve full source over the required period of time. Since a doubling of the number of airguns is typically equal to a 6 dB increase in sound level, the array was not ramped up if more than half of the airguns in the array were already firing.

Table 3. Total acoustic source operations during the Cascadia thrust zone marine geophysical survey.

Acoustic Source Operations	Number	Duration (hh:mm)
Gun Tests		**0:00**
Ramp-up	**2**	**1:03**
Day time ramp-ups from silence	**2**	
Day time ramp-ups from mitigation	**0**	
Night time ramp-ups from mitigation	**0**	
Full power survey acquisition		**47:32**
Partial power survey acquisition		**0:09**
Full/partial power line changes		**0:33**
Single airgun (40 in³)		**4:41**
Total time acoustic source was active		**53:58**

4.2. VISUAL MONITORING SURVEY SUMMARY

The PSOs continued visual observations immediately from the Carbotte project. There was a two minute line change between the end of a Carbotte survey line and the beginning of the Trehu survey. Visual monitoring began at 21:04 UTC on 3 July 2012 and continued until 3:45 UTC on 6 July 2012 when the *Langseth* continued acquisition on Carbotte survey lines. Visual monitoring was over a period of about 2.5 days. Monitoring was conducted by two PSOs each day between just before dawn until just after dusk, when it was too dark for the entire safety radius to be visible, averaging approximately 17 hours of visual observations per day.

Visual watches were held by two PSOs except during the scheduled meal hours for lunch and dinner when a single PSO continued visual monitoring, in addition to acoustic monitoring conducted by the PAM operator on duty while each PSO rotated for a meal break. Single PSO visual observations during these periods lasted a maximum of 45 minutes. In the event of a sighting event during a single PSO watch a second PSO would be notified and would immediately return to assist observations.

The acoustic source was active during the majority of both visual monitoring (98%) and acoustic monitoring (99%), as shown in Figure 5.

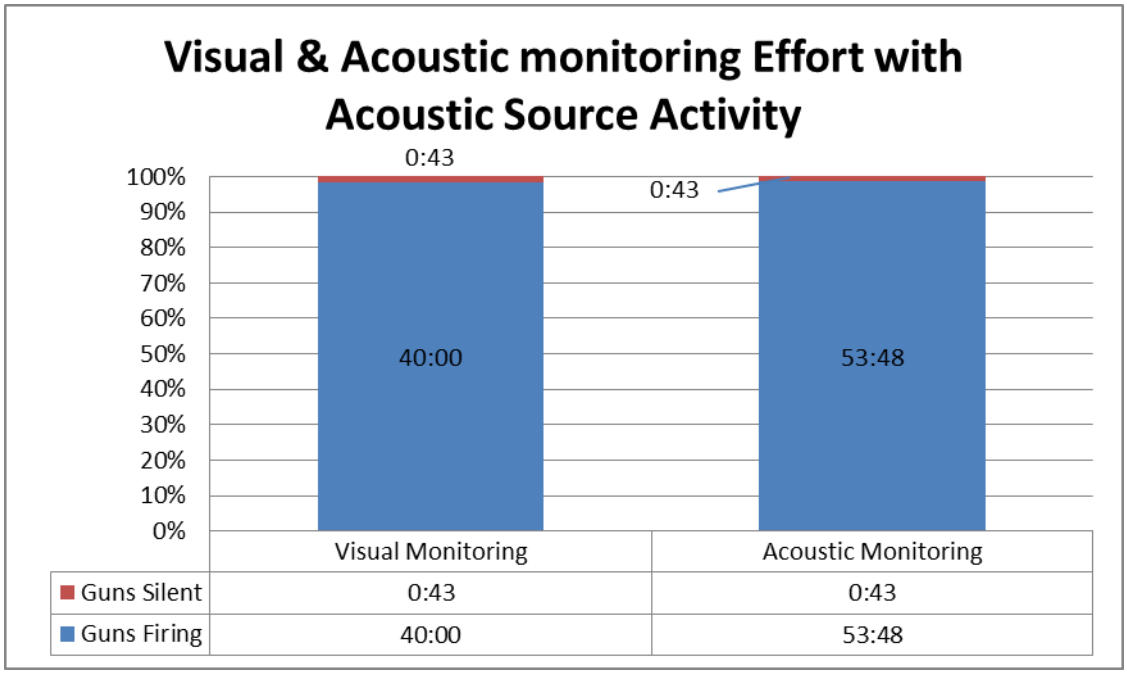

Figure 5. Duration of visual and acoustic monitoring effort while the acoustic source was active vs. silent.

Total visual monitoring effort, divided by monitoring effort while the acoustic source was active and monitoring effort while the source was silent, is listed in Table 5.

Table 4. Total visual monitoring effort.

Visual Monitoring Effort	Duration (hh:mm)
Total monitoring while acoustic source active	**40:00**
Total monitoring while acoustic source silent	**00:43**
Total monitoring effort	**40:43**

The PSOs preferred to conduct visual observations from the PSO tower, which provided the PSOs with a 360° view of the water around the vessel and acoustic source. However, visual watches would be conducted from the catwalk or bridge for any health or safety reason or during periods with high winds, large swells, or heavy rain. As Figure 6 demonstrates approximately 86% of visual monitoring was conducted from the PSO tower during the Cascadia Thrust Zone marine geophysical survey.

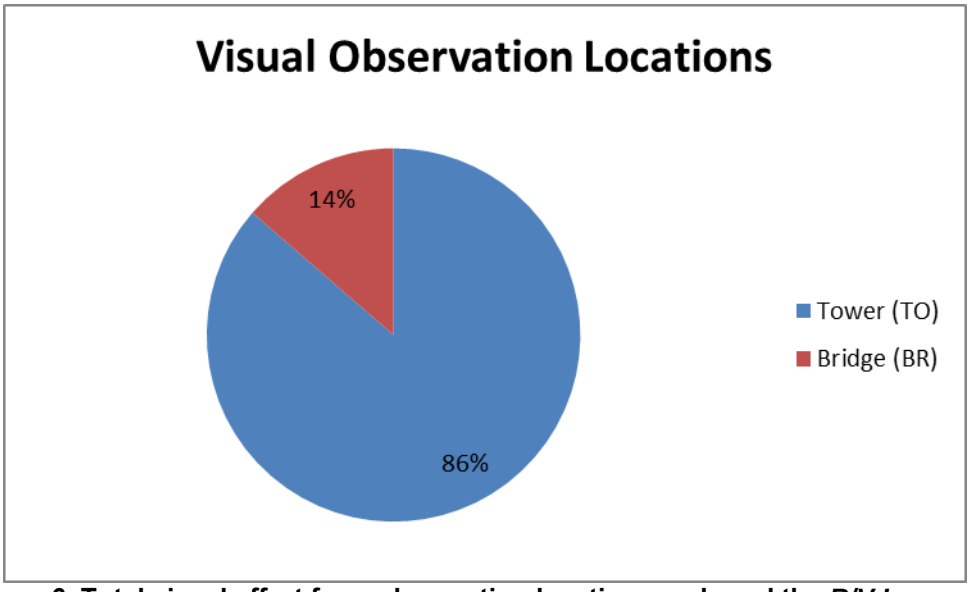

Figure 6. Total visual effort from observation locations on board the *R/V Langseth*.

4.3. ACOUSTIC MONITORING SURVEY SUMMARY

Acoustic monitoring began at 21:14 UTC on 3 July 2012 once the environment conditions allowed for the cable to be deployed without risk of entanglement. The hydrophone remained deployed and acoustic monitoring continued throughout the project with PSOs monitoring the hydrophones aurally and monitoring the *Pamguard* detection software visually both day and night. Acoustic monitoring for the project ended at 3:45 on 6 July 2012 when the acquisition of the final survey line was completed. Over the course of the project, PSOs conducted 54 hours 31 minutes of acoustic monitoring, all but 43 minutes occurred while the acoustic source was active (Table 6).

Table 5. Total passive acoustic monitoring (PAM) effort.

Passive Acoustic Monitoring Effort	Duration (hh:mm)
Total night time monitoring	**13:58**
Total day time monitoring	**40:33**
Total monitoring while acoustic source active	**53:48**
Total monitoring while acoustic source silent	**00:43**
Total acoustic monitoring	**54:31**

A delay in the deployment of the hydrophone cable prior to the start of the project resulted in 10 minutes of acoustic monitoring downtime that can be attributed to rough seas.

Table 6. Passive acoustic monitoring (PAM) downtime.

Date	Monitoring Suspended	Date	Monitoring Resumed	Duration acoustic monitoring suspended	Comments
2012-07-03	21:04	2012-07-03	21:14	00:10	Hydrophone cable retrieved due to a shallow depth and risk of entanglement with the seismic gear. Remained on board until environmental conditions improved.

4.4. SIMULTANEOUS VISUAL AND ACOUSTIC MONITORING SUMMARY

While visual observations began at 21:04 UTC 3 July 2012, acoustic observations began at 21:24 UTC, due to the hydrophone cable being deployed after the swells had dropped to avoid entanglement. Of the total observation effort performed by PSOs during this survey, visual monitoring accounted for 43% (40 hours 43 minutes) while acoustic monitoring accounted for 57% (54 hours 31 minutes). As displayed in Figure 7 there were 40 hours 33 minutes of simultaneous visual and acoustic observations conducted during this survey. Simultaneous visual and acoustic monitoring accounted for 74% of total acoustic monitoring and 99.5% of the total visual observation.

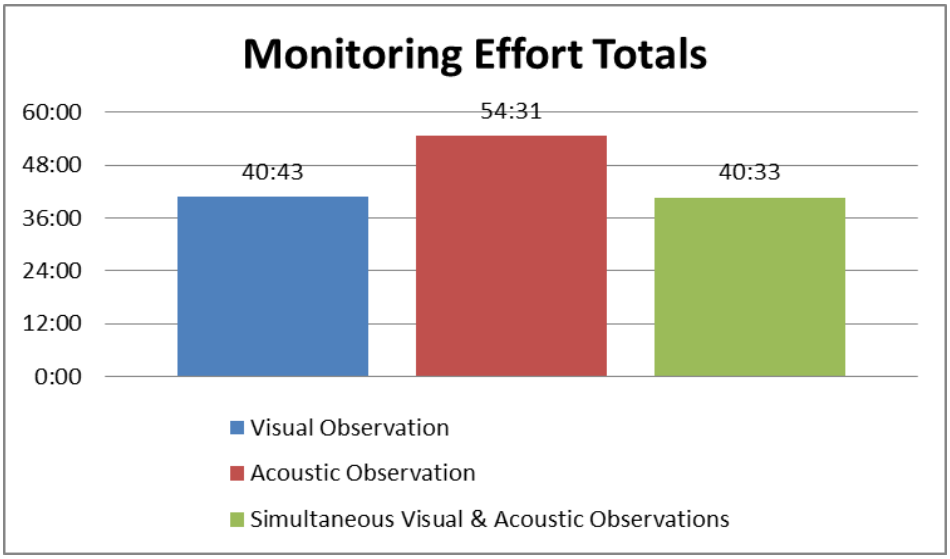

Figure 7. Total acoustic and visual monitoring effort.

4.5. ENVIRONMENTAL CONDITIONS

The visual monitoring effort for this project was conducted during favorable observation conditions. With an average of only 26% cloud cover and an average visibility of over nine kilometers, the 180/190 dB safety radii were visible 100% of the time. There was no precipitation or fog during this survey, however 36 hours of glare was recorded.

The Beaufort Sea states ranged from levels one through five for the entirety of the survey. (Figure 8).

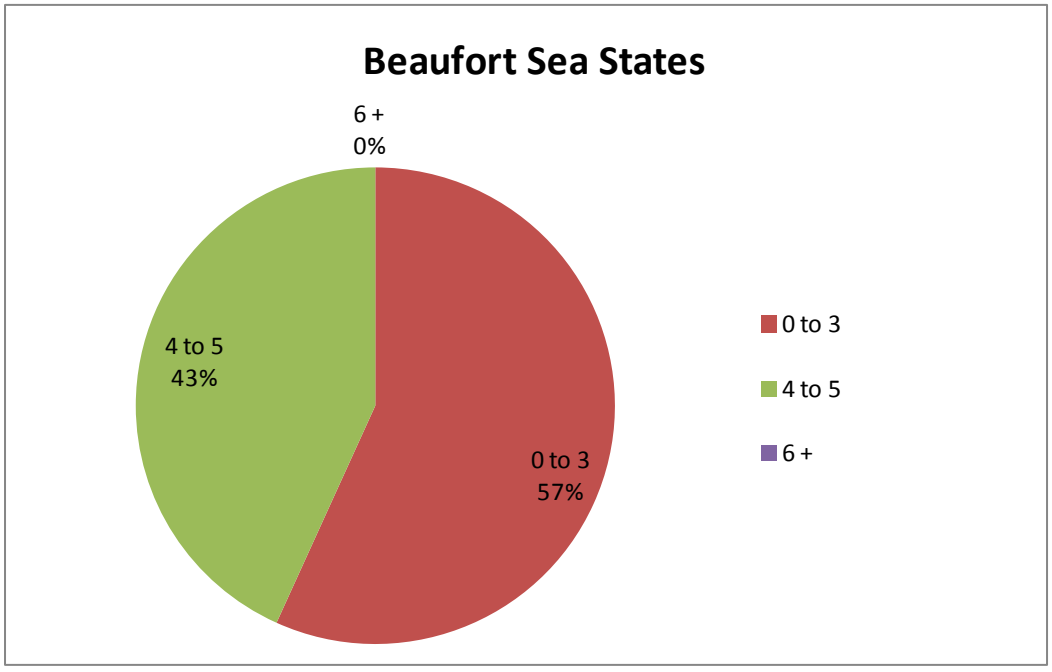

Figure 8. Beaufort sea state during visual monitoring over the Cascadia thrust zone marine geophysical survey.

Wind forces remained relatively stable throughout the survey with a minimum of three knots and a maximum of 23 knots. Forces from 10-21 knots were the average during the survey totalling 31.5 hours (Figure 9).

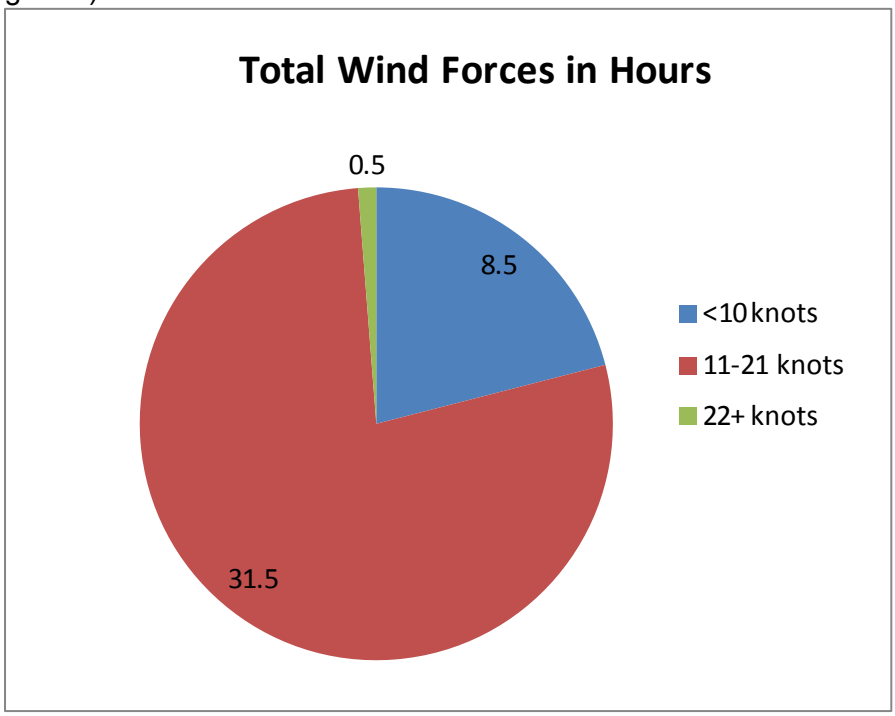

Figure 9. Average wind force during visual monitoring.

Swell height also remained relatively stable throughout the survey with 35 hours of swells under 2 meters, and only 5.5 hours of swells from 2-4 meters (Figure 10).

Figure 10. Swell heights while visual monitoring was conducted.

5. MONITORING AND DETECTION RESULTS

5.1. VISUAL DETECTIONS

Visual monitoring conducted during the Cascadia Thrust Zone marine geophysical survey resulted in the collection of 19 records of detection for protected species (summarized in Appendix E). One species of marine mammal were positively identified; detections were also made of one unidentified baleen whale and seven unidentified whales. The total number of detection events and total number of animals recorded by species is described in Table 7.

A complete list of bird species observed and identified in addition to the approximate number of individuals observed and the number of days on which they were observed can be found in Appendix F.

Table 7. Number of visual detection records collected for each protected species.

	Total Number of Detection Records	Total Number of Animals Recorded
Cetaceans		
Unidentified whale	7	11
Mysticetes		
Humpback whale	11	23
Unidentified baleen whale	1	2
TOTAL	**19**	**36**

There were many sightings of protected species during the Cascadia Thrust Zone marine geophysical survey; fewer sightings occurred on first and last days due to the project beginning late on 3 July 2012 and ending early in the day on 6 July 2012 (Figure 11). The majority of detections occurred on 5 July 2012 when there were 10 detections of protected species totalling 21 animals. The majority of which were humpback whales.

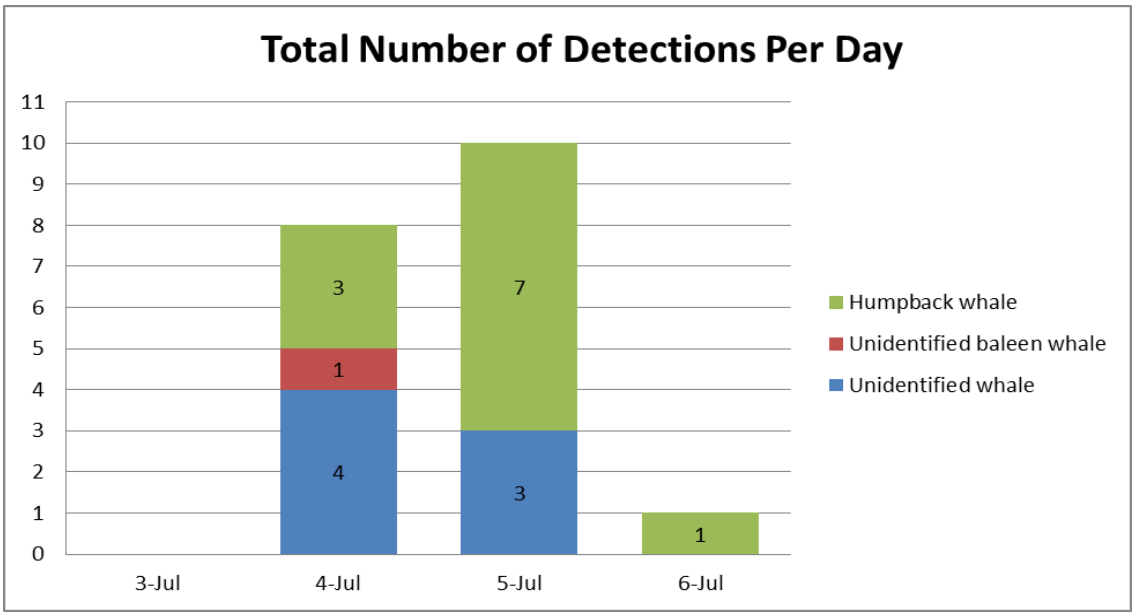

Figure 11. Number of protected species detections each day of the Cascadia Thrust Zone marine geophysical survey.

The acoustic source was active during all 19 protected species sightings. Figure 12 demonstrates the species detected compared to airgun activity.

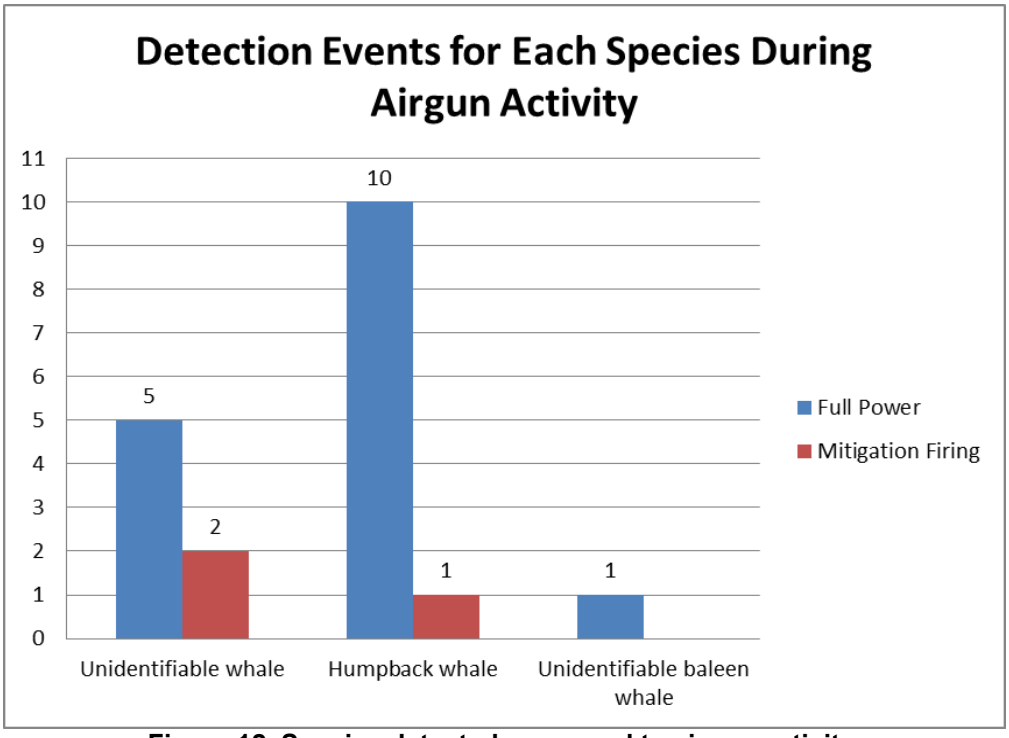

Figure 12. Species detected compared to airgun activity.

Table 8 demonstrates the average closest approach of protected species to the source at various volumes.

Table 8. Average closest approach of protected species to the acoustic source at various volumes.

Species Detected	Full Power (6560 in³)		Single Airgun 40 in³		Ramp-up / Other Reduced Volume		Not Firing	
	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)
Humpback whale	10	2101	1	200	-	-	-	-
Unidentified baleen whale	1	5664	-	-	-	-	-	-
Unidentified whale	6	3230	2	5845	-	-	-	-

All records of detection for protected species during the survey were for cetaceans. No pinnipeds were observed. Figure 13 demonstrates the total number of animals observed, per species, during the detection events. Humpback whales were by far the most abundant species and many of the unidentified whales that observed too far to identify were likely Humpback whales.

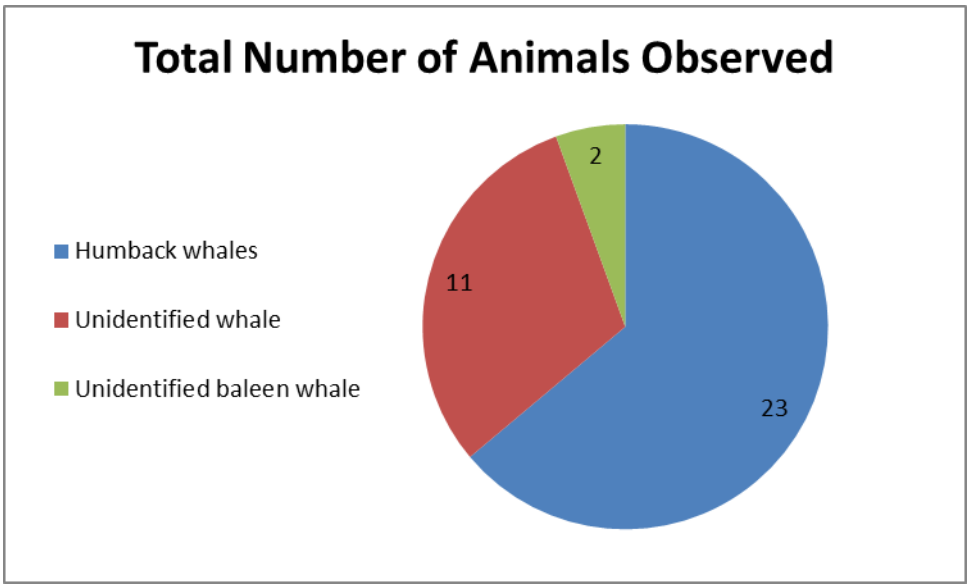

Figure 13. Number of individuals per species detected.

The spatial distribution of marine mammal detections can be seen in Figure 14.

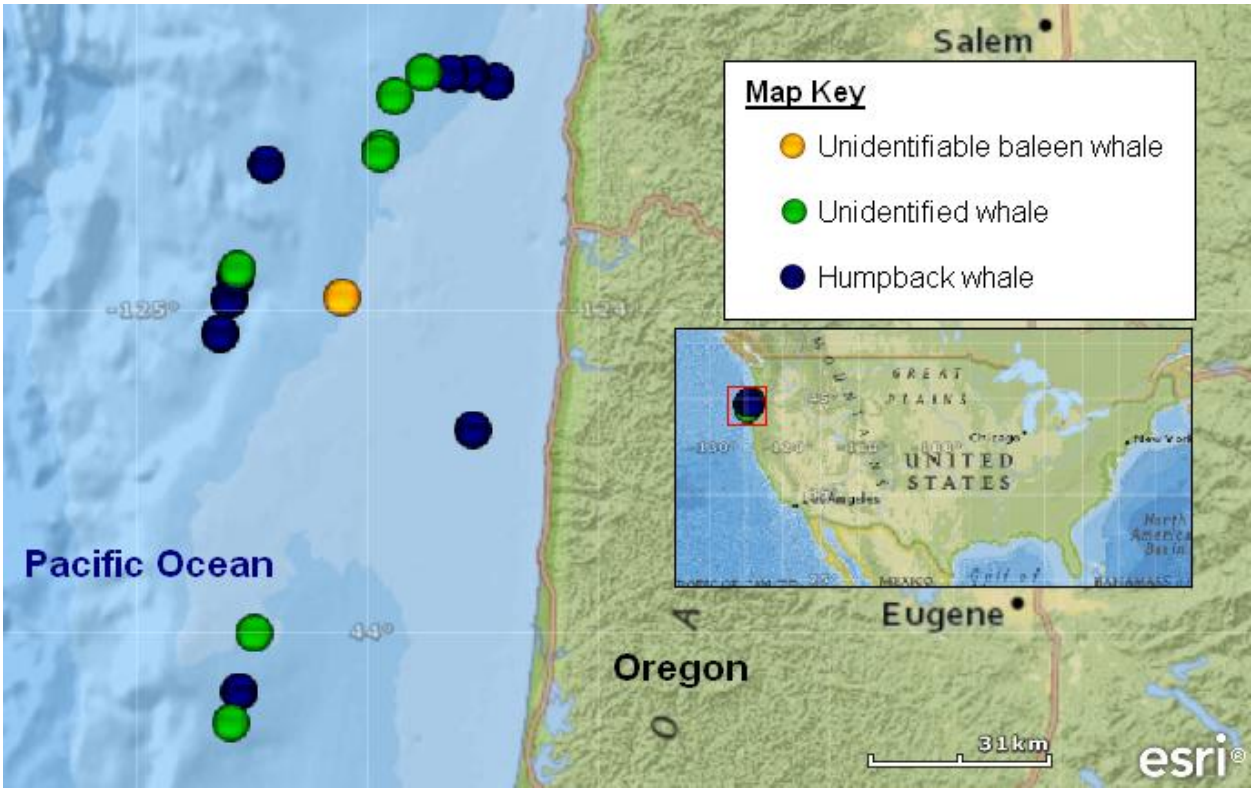

Figure 14. Marine mammal spatial distribution of detections from 3 July 2012 – 6 July 2012 on board the *Langseth*.

5.1.1. Cetacean Detections

5.1.1.1. Humpback whale

There were 23 individual humpback whales (*Megaptera novaeangliae*), observed in 11 sightings. Seven of these observations resulted in power-downs and two resulted in shut-downs. Two required no mitigation action. There was a total of 5 hours 02 minutes of mitigation down time, accounting for 94.97% of total downtime. The whales were noted to be in depths ranging from 70 to 404 meters. Group sizes ranged from 1 – 5 individuals. The closest approach to the vessel was 200 meters on July 5. Many of the humpbacks observed were very active; they were often observed breaching, lobtailing, spyhopping, and flipper slapping.

5.1.1.2. Unidentified baleen whale

There was one sighting of two individual unidentified baleen whales. They were observed at nearly six kilometers and thus required no mitigation action. This distance prevented observers from making a definite identification.

5.1.1.3. Unidentified whale

There were seven sightings of unidentified whales and 11 individuals observed during the survey. There was one power-down on July 5, resulting in sixteen minutes of mitigation downtime, accounting for 5.03% of total downtime. These detections often occurred over large distances making only the blow visible.

6. MITIGATION ACTION SUMMARY

There was 10 mitigation action implemented during the Cascadia Thrust Zone marine geophysical survey. Eight power-downs and two shut-downs of the acoustic source were implemented for protected species observed within the safety radii. Both shut-downs of the acoustic source occurred after the acoustic source had already been powered down. The total duration of downtime caused by mitigation actions (including ramp-up, if required) was 5 hours 18 minutes during the survey. The number and duration of mitigation actions is summarized in Table 9.

Table 9. Number and duration of mitigation actions implemented during the Cascadia thrust zone marine geophysical survey.

Mitigation Action	Cetaceans	
	Number	Duration
Delayed Ramp-up	0	0:00
Power-down	8	2:19
Shut-down	2	2:59
Total	**10**	**5:18**

The allotted 12 'takes' for humpback whales was exceeded on 5 June 2012 when there were several humpback whale detections occurring at the same time. At the time the 'takes' were exceeded the PSOs began using the 160 dB safety radius for humpback whales. If a whale was observed within the 160 dB safety radius and identified as a humpback the acoustic source would be powered-down. Additionally, if the whales approached the 160 dB safety radius of the single source then the array would be shut-down and remain inactive until 30 minutes had passed since the last visual sighting. After the 'takes' were exceeded an additional 11 humpback whales were observed. The exceeded take reports can be found in Appendix G.

Nine of the ten mitigation actions were implemented for humpback whales, accounting for 95% of mitigation downtime. One mitigation action was implemented for an unidentified whale, accounting for 5% of mitigation downtime (Table 10).

Table 10. Mitigation actions and downtime duration by species.

Species	Number of Delayed ramp-ups	Number of Power-downs	Number of Shut-downs	Duration of Downtime	Percentage of Mitigation Downtime
Unidentified whale	-	1	-	0:16	**5%**
Humpback whale	-	7	2	5:02	**95%**

Each mitigation action that was implemented during the survey is summarized in Table 11.

Table 11. Summary of each mitigation action implemented during the Cascadia thrust zone marine geophysical survey.

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Source/Power Level	Mitigation Action	Total Duration of Mitigation Event
4-Jul	1	Humpback whale	2	Full power	1767 m / Full power	Power down	0:18

4-Jul	2	Humpback whale	2	Full power	900 m / Not firing	Power / Shut down	1:20
4-Jul	3	Humpback whale	1	Full power	1500 m / Mitigation firing	Power down	0:27
5-Jul	10	Humpback whale	2	Full power	1700 m / Full power	Power down	0:11
5-Jul	11	Unidentified whale	1	Full power	1702 m / Full power	Power down	0:16
5-Jul	14	Humpback whale	3	Full power	300 m / Mitigation firing	Power down	0:47
5-Jul	18	Humpback whale	5	Full power	350 m / Not firing	Power / Shut down	1:56
6-Jul	19	Humpback whale	2	Full power	4300 m / Mitigation firing	Power down	0:03

6.1. MARINE MAMMALS KNOWN TO HAVE BEEN EXPOSED TO 160 DB OF RECEIVED SOUND LEVELS

NMFS granted an IHA to L-DEO for a marine seismic survey allowing Level B harassment takes (exposure to sound pressure levels greater than or equal to 160 dB re: 1 µPa (rms)) for 24 marine mammal species: seven mysticetes and 13 odontocete species, and four pinniped species. Direct visual observations recorded by PSOs of one species of marine mammals for which takes were granted in the IHA provide a minimum estimate of the actual number of cetaceans exposed to received sound levels of 180/190 dB and 160 dB.

During the Cascadia thrust zone marine geophysical survey 15 humpback whales and one unidentified whale were observed within the 180 dB safety radius. Additionally, eight humpback whales, ten unidentified whales, and two unidentified baleen whales were observed within the 160 dB safety radius, where Level B harassment is expected to occur, while the acoustic source was active (Table 12).

Table 12. Level B Harassment 'takes' authorized by NMFS IHA for the Cascadia thrust zone marine geophysical and number of known individuals exposed to 160 dB and 180/190 dB through visual observations.

Species	IHA Authorized Takes	Number of animals exposed to 180/190 dB	Number of animals exposed to 160 dB
Mysticetes			
North Pacific right whale	0	0	0
Gray whale	35	0	0
Humpback whale	12	15	23
Minke whale	7	0	0
Sei whale	2	0	0
Fin whale	18	0	0
Blue whale	3	0	0
Odontocetes			
Sperm whale	15	0	0
Unidentified *Kogia spp.*	10	0	0
Cuvier's beaked whale	6	0	0
Baird's beaked whale	17	0	0

Unidentified *Mesoplodon spp.*	25	0	0
Striped dolphin	2	0	0
Short-beaked common dolphin	238	0	0
Pacific white-sided dolphins	500	0	0
Northern right whale dolphin	184	0	0
Risso's dolphin	160	0	0
Killer whale	0	0	0
Harbor porpoise	7,314	0	0
Dall's porpoise	1,199	0	0
Pinnipeds			
Northern fur seal	1,197	0	0
California sea lion	0	0	0
Steller sea lion	188	0	0
Pacific harbor seal	3,380	0	0
Northern elephant seal	656	0	0
Unidentified Cetaceans			
Unidentified whale	-	1	10
Unidentified baleen whale	-	0	2

These numbers are very likely to be an underestimate and provide the absolute minimum number of animals actually exposed. When in water shallower than 1000 meters the 160 dB safety radius ranged from ~14 km to ~23.5 km making is impossible to observe the entire safety radius. It is also possible that estimated numbers of animals recorded during each sighting event were underestimates, some animals not being seen or having moved away before they were observed. Table 13 describes the behavior of all animals, including unidentified species, which were exposed to 160 dB for the duration they were observed.

Table 13. Behavior of species exposed to 160 dB.

Species	Detection No.	No. of Animals	Initial behavior	Initial direction in relation to vessel	Subsequent and Final behavior	Subsequent and Final direction in relation to vessel
Humpback whale	1	2	breaching	unknown	diving	unknown
Humpback whale	2	2	blowing	towards vessel	lobtailing / diving	perpendicular, behind vessel
Humpback whale	3	1	blowing	perpendicular, ahead of vessel	fluking	perpendicular, ahead of vessel
Unidentified whale	4	1	blowing	unknown	blowing	unknown
Unidentified whale	5	2	blowing	parallel, opposite direction	blowing	parallel, opposite direction
Unidentified whale	6	1	blowing	unknown	unknown	unknown
Unidentified whale	7	2	blowing	away from vessel	blowing	away from vessel
UID baleen whale	8	2	blowing	parallel, opposite direction	diving	parallel, opposite direction

Unidentified whale	9	3	blowing	parallel, opposite direction	blowing	parallel, opposite direction
Humpback whale	10	2	breaching	parallel, opposite direction	lobtailing / fluking	parallel, opposite direction
Unidentified whale	11	1	blowing	unknown	diving	unknown
Humpback whale	12	1	blowing	away from vessel	fluking	away from vessel
Humpback whale	13	2	blowing	perpendicular, ahead of vessel	fluking	parallel, opposite direction
Humpback whale	14	3	blowing	perpendicular, ahead of vessel	spyhop / roll / fluke	parallel, opposite direction
Humpback whale	15	2	blowing	away from vessel	fluking	away from vessel
Humpback whale	16	1	breaching	parallel, same direction	fluking	parallel, same direction
Unidentified whale	17	1	blowing	parallel, opposite direction	roll / dive	variable
Humpback whale	18	5	blowing	parallel, opposite direction	fluking	unknown
Humpback whale	19	2	blowing	away from vessel	fluking	away from vessel

6.1.1. Cetaceans

6.1.1.1. Humpback whale

Humpback whales (*Megaptera novaeangliae*) were the only positively identified marine mammal observed to be exposed to noise levels constituting Level-B harassment during the Trehu survey. Eleven sighting events totaling 23 animals were observed within the 160 dB safety radius; 15 of these 23 animals were observed to be exposed to received sound pressure levels of 180 dB or greater. The humpbacks were observed to be in groups ranging from one to five animals. Of the 23 animals observed six were identified as juveniles.

During six of the eleven sightings the whales were observed to exhibit active behavior such at breaching, lobtailing, spyhopping, flipper slapping, and rolling. Mitigation actions were implemented during seven of the sightings. Due to the high density of humpback whales the allotted 'takes' were exceeded by 11 animals in one day. Once the allotted 'takes' for humpbacks had been exceeded the 160 dB safety radius was used as the 'power-down' radius for humpback whales.

6.1.1.2. Unidentified baleen whale

There was one sighting of unidentified baleen whales totalling two animals; one of which was identified as a juvenile. The whales remained further than 5 km from the vessel and were observed traveling in the opposite direction, making ~5 minute dives before surfacing and blowing 2-4 times.

6.1.1.3. Unidentified whale

There were seven sightings of unidentified whales totalling 11 animals; one of which was identified as a juvenile. Only the blows of these whales were observed, often at great distance, making identification hard. Of the 11 animals only one entered the 180 dB safety radius resulting in a power-down of the acoustic source. Most of these animals were observed in the same area as humpback whales and were likely humpback whales as well.

6.2. IMPLEMENTATION AND EFFECTIVENESS OF THE BIOLOGICAL OPINIONS'S ITS AND IHA

In order to minimize the Level-B incidental taking of marine mammals and sea turtles during the Cascadia thrust zone marine geophysical survey, mitigation measures were implemented whenever these protected species were seen near or within the safety radii designated in the IHA. Power-downs and shut-downs were implemented for mysticetes and unidentified cetaceans.

Additional mitigation measures specific to the Cascadia thrust zone survey required that if a North Pacific right whale (*Eubalaena japonica*) or a killer whale (*Orcinus orca*) were sighted, the airgun array would be shut-down regardless of the distance of the animal(s) to the sound source and that the array would not resume firing until 30 minutes after the last documented sighting of the whale. The acoustic array was also to be shut-down if a killer whale was acoustically detected on the PAM system. Waiting 30 minutes after the animals was last acoustically detected before resuming use of the acoustic source. While neither of these species was positively identified during the Cascadia thrust zone survey, numerous large unidentified whales were observed.

Part of the survey occurred in a humpback whale feeding area. Even though the survey lasted only 2.5 days the allotted 'takes' for humpbacks were exceeded within 1.5 days due to the high density of whales.

7. ACKNOWLEDGEMENTS

The Protected Species Observers on board *Langseth* during the Cascadia thrust zone marine geophysical survey in the northeastern Pacific Ocean would like to thank the National Science Foundation and Lamont-Doherty Earth Observatory for the opportunity to work on this project. It was a pleasure to work with Dr. Suzanne Carbotte, as well as Meagan Cummings, the Marine Environmental Safety Coordinator for L-DEO. We would also like to thank the marine crew and science team on board the *R/V Langseth* for their assistance and hospitality.

We would like to thank the following individuals for their considerable help in making the program a success.

- Meagan Cummings and Jeff Rupert from L-DEO and Holly Smith from NSF for their assistance, planning and preparation for the cruise.
- Rebecca Snyder from RPS for her support and installation of the PAM system.
- Matthew Dellinger from RPS for providing logistical support for the project.
- We also thank Meagan Cummings for reviewing this report.

We would like to extend our sincere thanks and gratitude to everyone who helped support this project as it would not have been possible without the efforts and assistance of the many individuals and organizations involved.

8. LITERATURE CITED

LGL Ltd., Environmental Research Associates, 2012. "Environmental Assessment of a Marine Geophysical Survey by the *R/V Marcus G. Langseth* in the Northeastern Pacific Ocean, June-July 2012".

APPENDIX A: **Incidental Harassment Authorization for the Cascadia thrust zone marine geophysical survey**

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUN 2 7 2012

Meagan J. Cummings
Marine Environmental & Safety Coordinator
Department of Marine Operations
Lamont-Doherty Earth Observatory
P.O. Box 1000
Palisades, New York, 10964-8000

Dear Ms. Cummings:

Enclosed is an Incidental Harassment Authorization (IHA) issued to the Lamont-Doherty Earth Observatory, under the authority of section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*), to harass small numbers of marine mammals, by Level B harassment, incidental to the R/V *Marcus G. Langseth*'s marine geophysical survey in the northeastern Pacific Ocean during July, 2012.

You are required to comply with the conditions contained in the IHA which have also been included as Terms and Conditions for incidental take of endangered species in the Biological Opinion. In addition, you must submit a report to the National Marine Fisheries Service's (NMFS) Office of Protected Resources within 90 days of the completion of the cruise. The IHA requires monitoring of marine mammals by qualified individuals before, during, and after seismic activities and reporting of marine mammal observations, including species, numbers, and behavioral modifications potentially resulting from this activity.

If you have any questions concerning the IHA or its requirements, please contact Howard Goldstein, Jeannine Cody, or Jolie Harrison, Office of Protected Resources, NMFS, at 301-427-8401.

Sincerely,

Helen M. Golde
Acting Director
Office of Protected Resources

Enclosures

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUN 27 2012

Incidental Harassment Authorization

We hereby authorize Lamont-Doherty Earth Observatory (L-DEO), P.O. Box 1000, Palisades, New York 10964-8000, under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1371(a)(5)(D)), to harass small numbers of marine mammals incidental to a marine geophysical (seismic) survey conducted by the R/V *Marcus G. Langseth* (*Langseth*) in the northeastern Pacific Ocean, July, 2012:

1. This Authorization is valid from July 1 through August 1, 2012.

2. This Authorization is valid only for the *Langseth*'s specified activities associated with seismic survey operations as specified in the Observatory's Incidental Harassment Authorization application and the National Science Foundation's (NSF) associated Environmental Assessment in the following specified geographic area:

(i) An area bounded by approximately 43 to 45° North by approximately 124 to 125° West.

3. Species Authorized and Level of Takes

(a) This authorization limits the incidental taking of marine mammals, by Level B harassment only, to the following species in the waters of the northeastern Pacific Ocean:

(i) Mysticetes – see Table 1 (attached) for authorized species and take numbers.

(ii) Odontocetes – see Table 1 (attached) for authorized species and take numbers.

(iii) Pinnipeds – see Table 1 (attached) for authorized species and take numbers.

(iii) During the seismic activities, if the Holder of this Authorization encounters any marine mammal species under NMFS jurisdiction during seismic activities that are not listed in Table 1 (attached) for authorized taking and are likely to be exposed to sound pressure levels (SPLs) greater than or equal to 160 dB re 1 µPa (rms), then the Holder of this Authorization must alter speed or course, power-down, or shut-down the airguns to avoid take.

(b) This Authorization prohibits the taking by injury (Level A harassment), serious injury, or death of any of the species listed in Condition 3(a) above or the taking of any kind of any other species of marine mammal thus, it may result in the modification, suspension or revocation of this Authorization.

4. This Authorization limits the methods authorized for taking by Level B harassment to the following acoustic sources without an amendment to this Authorization:

(i) A 36 Bolt airgun array with a total capacity of 6,600 in^3 (or smaller);

(ii) A multi-beam echosounder;

(iii) A sub-bottom profiler; and

(iv) An acoustic release transponder used to communicate with ocean bottom seismometers (OBS).

5. The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Office of Protected Resources, National Marine Fisheries Service (NMFS), at 301-427-8401.

6. Mitigation and Monitoring Requirements

The Holder of this Authorization is required to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable impact on affected marine mammal species or stocks:

(a) Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (PSVOs) (except during meal times and restroom breaks, when at least one PSVO shall be on watch) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew shall also assist in detecting marine mammals, when practicable. PSVOs shall have access to reticle binoculars (7 x 50 Fujinon), big-eye binoculars (25 x 150), laser range-finding binoculars, and thermal imaging cameras. PSVO shifts shall last no longer than 4 hours at a time. PSVOs shall also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

(b) PSVOs shall conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water.

(c) Record the following information when a marine mammal is sighted:

(i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

(ii) Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, and sun glare; and

(iii) The data listed under Condition 6(c)(ii) shall also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

(d) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One NMFS-qualified Protected Species Observer (PSO) and/or expert bioacoustician (i.e., Protected Species Acoustic Observer [PSAO]) shall monitor the PAM at all times in shifts no longer than 6 hours. An expert bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

(e) Do and record the following when an animal is detected by the PAM:

(i) Notify the on-duty PSVO(s) immediately of the presence of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;

(ii) Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection can also be recorded for further analysis.

(f) Visually observe the entire extent of the exclusion zone (EZ) (180 dB re 1 µPa [rms] for cetaceans and 190 dB re 1 µPa [rms] for pinnipeds; see Table 2 [attached] for distances) using NMFS-qualified PSVOs, for at least 30 minutes prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the EZ, L-DEO must delay the seismic survey until the marine mammal(s) has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the PSVO shall wait 30 minutes. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 µPa (rms), L-DEO may start the second airgun without observing the entire EZ for 30 minutes prior, provided no marine mammals are known to be near the EZ (in accordance with Condition 6[h] below).

(g) Establish a 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) EZ for marine mammals before the 4-string airgun array (6,600 in^3) is in operation; and a 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) EZ before a single airgun (40 in^3) is in operation, respectively. See Table 2 (attached) for distances and EZs.

(h) Ramp-up procedures at the start of seismic operations or after a shut-down - Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shut-down for more than 8 minutes, which means start the smallest gun first and add airguns in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the PSVOs shall monitor the 180 dB EZ for cetaceans or the 190 dB EZ for pinnipeds, and if marine mammals are sighted within or about to enter the relevant EZ, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from a shut-down or at the beginning of seismic operations requires that the PSVOs be able to view the full EZ as described in Condition 6(f).

(i) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant EZ. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the EZ, further mitigation measures, such as a power-down or shut-down, shall be taken.

(j) Power-down or shut-down the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant EZ (as defined in Table 1, attached). A shut-down means all operating airguns are shut-down (i.e., turned off). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun, which reduces the EZ to the degree that the animal(s) is no longer in or about to enter it.

(k) Following a power-down, if the marine mammal approaches the smaller designated EZ, the airguns must then be completely shut-down. Airgun activity shall not resume until the PSVO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales). Following a shut-down, the *Langseth* may resume airgun operations following ramp-up procedures described in Condition(h).

(l) Procedures after an extended power-down – Monitor the full 180 dB EZ for cetaceans and the full 190 dB EZ for pinnipeds. The *Langseth* may resume full power operations anytime after the entire array has been powered-down for more than 8 minutes. Resuming operations at full power after an extended power-down of more than 8 minutes requires that the PSVOs be able to view the full EZ as described in Condition 6(f). If the

PSVO sees a marine mammal within or about to enter the relevant EZs, then the *Langseth* will implement a course/speed alteration or power-down.

(m) Marine seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant EZs are visible and can be effectively monitored.

(n) No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant EZ cannot be effectively monitored by the PSVO(s) on duty.

(o) If a North Pacific right whale (*Eubalaena japonica*) is visually sighted, the airgun array shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting.

(p) If killer whales (*Orcinus orca*) are visually sighted or detected acoustically, the airguns shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting or acoustic detection.

(q) Communicate with NMFS Northwest Fisheries Science Center (Brad.Hanson@noaa.gov, 206-300-0282), NMFS Northwest Regional Office (Lynne.Barre@noaa.gov, 206-718-3807 or Brent.Norberg@noaa.gov, 206-526-6550), The Whale Museum (hotline@whalemuseum.org, 1-800-562-8832) and/or Orca Network (infor@orcanetwork.org, 1-866-672-2638) for near real-time reporting of the whereabouts of Southern Resident killer whales.

(r) To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours and OBS operations (i.e., deploy/retrieve) to nighttime hours.

(s) To the maximum extent practicable, plan to conduct seismic surveys (especially when near land) from the coast (inshore) and proceed towards the sea (offshore) in order to avoid trapping marine mammals in shallow water.

7. Reporting Requirements

The Holder of this Authorization is required to:

(a) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the *Langseth*'s three cruises. This report must contain and summarize the following information:

(i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;

(ii) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shut-downs), observed throughout all monitoring activities.

(iii) An estimate of the number (by species) of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 µPa (rms) and/or 180 dB re 1 µPa (rms) for cetaceans and 190 dB re 1 µPa (rms) for pinnipeds with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on reported and corrected empirical values for the 36 airgun array and modeling measurements for the single airgun) to the seismic activity at received levels greater than or equal to 160 dB re 1 µPa (rms) and/or 180 dB re 1 µPa (rms) for cetaceans and 190 dB re 1 µPa (rms) for pinnipeds with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

(iv) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (ITS) (attached); and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act-listed marine mammals.

(b) Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, within 30 days after receiving comments from NMFS on the draft report. If NMFS decides that the draft report needs no comments, the draft report shall be considered to be the final report.

(c) In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), L-DEO shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov and the Northwest Regional Stranding Coordinator at 206-526-6550 (Brent.Norberg@noaa.gov). The report must include the following information:

(i) Time, date, and location (latitude/longitude) of the incident; the name and type of vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24 hours preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with L-DEO to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. L-DEO may not resume their activities until notified by NMFS via letter, email, or telephone.

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), L-DEO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov). The report must include the same information identified in Condition 7(c)(i) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate.

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), L-DEO shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov) within 24 hours of the discovery. L-DEO shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

9. L-DEO is required to comply with the Terms and Conditions of the ITS corresponding to NMFS's Biological Opinion issued to both NSF and NMFS's Office of Protected Resources (attached).

10. A copy of this Authorization and the ITS must be in the possession of all contractors and PSOs operating under the authority of this Incidental Harassment Authorization.

JUN 2 7 2012

Helen M. Golde
Acting Director
Office of Protected Resources
National Marine Fisheries Service

Date

Attachments

Attachment

Table 1. Authorized Take Numbers for Each Marine Mammal Species during the Cascadia Thrust Zone Seismic Survey in the northeastern Pacific Ocean.

Species	Authorized Take in the Cascadia Thrust Zone Study Area
Mysticetes	
North Pacific right whale (*Eubalaena japonica*)	0
Gray whale (*Eschrichtius robustus*)	35
Humpback whale (*Megaptera novaeangliae*)	12
Minke whale (*Balaenoptera acutorostrata*)	7
Sei whale (*Balaenoptera physalus*)	2
Fin whale (*Balaenoptera borealis*)	18
Blue whale (*Balaenoptera musculus*)	3
Sperm whale (*Physeter macrocephalus*)	15
Unidentified *Kogia* spp. Pygmy sperm whale (*Kogia breviceps*) and/or Dwarf sperm whale (*Kogia sima*)	10
Cuvier's beaked whale (*Ziphius cavirostris*)	6
Baird's beaked whale (*Berardius bairdii*)	17
Unidentified *Mesoplodon* beaked whale (*Mesoplodon* spp.)	25
Striped dolphin (*Stenella coeruleoalba*)	2
Short-beaked common dolphin (*Delphinus delphis*)	238
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	500
Northern right whale dolphin (*Lissodelphis borealis*)	184

Risso's dolphin (*Grampus griseus*)	160
Killer whale (*Orcinus orca*)	0
Harbor porpoise (*Phocoena phocoena*)	7,314
Dall's porpoise (*Phocoenoides dalli*)	1,199
Pinnipeds	
Northern fur seal (*Callorhinus ursinus*)	1,197
California sea lion (*Zalophus californianus*)	0
Steller sea lion (*Eumetopias jubatus*)	188
Pacific harbor seal (*Phoca vitulina richardsi*)	3,380
Northern elephant seal (*Mirounga angustirostris*)	656

Table 2. Exclusion Zone Radii for Triggering Mitigation.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances (m)		
			Shut-down EZ for Pinnipeds 190 dB	Shut-down EZ for Cetaceans 180 dB	Level-B Harassment Zone 160 dB
Single Bolt airgun 40 in^3	6 to 15	Shallow (<100)	150	296	1,050
		Intermediate (100 to 1,000)	18	60	578
		Deep (>1,000)	12	40	385

4 strings 36 airguns 6,600 in^3	12	Shallow (<100)	770	2,250	23,470
		Intermediate (100 to 1,000)	615	1,810	13,935
		Deep (>1,000)	460	1,100	4,400

APPENDIX B: Basic Summary Data Form

BASIC DATA FORM				
LDEO Project Number		MGL1211		
Seismic Contractor		Lamont-Doherty Earth Observatory of Columbia University		
Area Surveyed During Reporting Period		Cascadia Thrust Zone in the Northeast Pacific Ocean		
		Approximately between 43 to 45°N and 124 to 125°W		
Survey Type		OBS		
Vessel and/or Rig Name		*R/V Marcus G. Langseth*		
Permit Number		IHA granted by NMFS on 27 June 2012		
Location / Distance of Airgun Deployment		232 meters aft of PSO tower		
Water Depth	**Min**	~50m		
	Max	~1000m		
Dates of project		3 July 2012	THROUGH	6 July 2012
Total time airguns operating – all power levels:		53 hours 58 minutes		
Time airguns operating at full power on survey lines:		47 hours 32 minutes		
Time airguns operating at partial power on survey lines:		9 minutes		
Time airguns operating at full/partial power on line changes:		33 minutes		
Amount of time mitigation gun (40 in³) operations:		4 hours 41 minutes		
Amount of time in ramp-up:		1 hour 03 minutes		
Number daytime ramp-ups:		2		
Number of night time ramp-ups:		0		
Number of ramp-ups from mitigation source:		0		
Amount of time conducted in airgun testing:		None		
Duration of visual observations:		40 hours 43 minute		
Duration of observations while airguns firing:		40 hours		
Duration of observation during airgun silence:		43 minutes		
Duration of acoustic monitoring:		54 hours 31 minutes		
Duration of acoustic monitoring while airguns firing:		53 hours 48 minutes		
Duration of acoustic monitoring during airgun silence:		43 minutes		
Duration of simultaneous acoustic and visual monitoring:		40 hours 33 minutes		
Lead Protected Species Observer:		Heidi Ingram		
Protected Species Observers:		Jami Allen		
		Katie Douglas		
		Tatiana Moreno		
Acoustic Observer:		Emily Ellis		
Number of Marine Mammals Visually Detected:		19		
Number of Marine Mammals Acoustically Detected:		0		
Number of acoustic detections confirmed by visual sighting:		0		
Number of visual sighting confirmed by acoustic detection:		0		
Number of Sea Turtles detected:		0		
List Mitigation Actions (eg. Power-downs, shut-downs, ramp-up delays)		8 power-downs, 2 shut-downs		
Duration of operational downtime due to mitigation:		5 hours 18 minutes		

APPENDIX C: Passive Acoustic Monitoring System Specifications

Passive Acoustic Monitoring System Specifications

Main cable and spare cable:

Mechanical Information

Length 250m			
Diameter	14mm over cable	32mm over mouldings	64mm over connectors
Weight 60kg			
Connector	CEEP 39 pin		

Hydrophone elements

Hydrophone 1	Sphere 1	Broad band	2 kHz to 200 kHz	(3dB points)
Hydrophone 2	Sphere 2	Broad band	2 kHz to 200 kHz	(3dB points)
Hydrophone 3	Sphere 3	Broad band	2 kHz to 200 kHz	(3dB points)
Hydrophone 4	Sphere 4	Low frequency	75Hz to 30 kHz	(3dB points)

Depth Capability 100m

Spacing between elements 1 & 2 (for HF detection)	0.25m	0.16mSecs
Spacing between elements 2 & 3 (for HF detection)	1.2m	0.8mSecs
Spacing between elements 3 & 4 (for LF detection)	1.2m	0.8mSecs

Interface unit Array 1 outputs

Broad band channel sensitivity	-166dB re 1V/uPa
Low frequency channel sensitivity	-157dB re 1V/uPa

Deck cable specification

Length	100m
Diameter	14mm
Connectors	39 pin ITT female
Flying lead for onboard connection	
Connector Diameter	64mm

Inboard Deck Cable
Deck cable specification

Length	1m
Diameter	14mm
Connectors	39 pin ITT male
Flying lead for onboard connection	
Connector Diameter	64mm

APPENDIX D: PAM Hydrophone Deployment on the *R/V Marcus Langseth*

PAM hydrophone deployment and retrieval procedure on the *R/V Marcus G. Langseth*

The hydrophone deployment procedure is a "living" document and may be altered at any time to reflect changes in deployment over time.

Overview

The research vessel *Langseth* is equipped with a towed PAM array system comprised of a low frequency laptop, a high frequency laptop, a data processing unit, a 100m deck cable, and a 250m linear hydrophone cable with 4 hydrophones and a depth gauge at the last 5m of the cable (Figure D.14). The system is capable of detected a broad range of marine mammal vocalizations due to three of the hydrophone elements having a broadband frequency range of 2 to 200kHz while the fourth hydrophone has a shorter frequency range of 75 to 30kHz for lower frequency detections and all four hydrophones having preamplifiers.

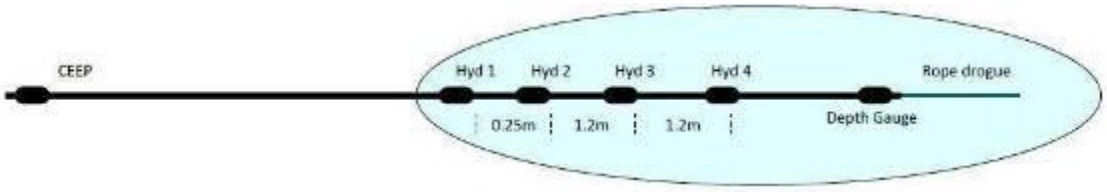

Figure D.16: Diagram of Linear Hydrophone Array.

The two laptops and data processing unit are set up in the main lab with a GPS cable feed (INGGA string) directly from the ship's navigation system to the low frequency laptop (Figure D. 15). The data processing unit connects to the 250m hydrophone cable through a 100m deck cable that is run from the main lab out to the gun deck. Both the deck cable in use and the spare are run from the main lab out to out to the gun deck just in case one failed because the cable had to be run through the bulk head which can only be done while in port. The 250m hydrophone cable is wound on a section of a deckhead winch on the port side of the gun deck (Figure D. 16). From the winch the hydrophone cable is fed astern and pulled further port by a line secured by a yale grip to the port sponson. (Figure D.17). An 8m rope drogue was secured to the end of the hydrophone cable with zip ties with a 9kg shackle secured to the end of the rope drogue with a knot and tape (Figure D.18). Second four lengths of chain weighing approximately 2.5kg each were secured on the cable with tape, 3m, 45m, 96, and 132m up from the depth gauge (Figure D.19). The hydrophone is deployed approximately 150m from the stern and 50m before the center of string. Being that the hydrophone cable is free and independent of the guns the cable is always retrieved before port gun strings are moved.

Figure D.17: PAM Laptops and data processing unit setup.

Figure D.18: Hydrophone cable on winch.

Figure D.19: Hydrophone cable secured by a yale grip to the port sponson.

Figure D.20: Rope drogue and first chain weight secured near hydrophone elements.

Figure D.21: One of the four lengths of chain used to weigh down the cable.

Deployment

- Make sure the data processing unit is off.
- Make sure the deck cable is disconnected from the hydrophone cable.
- Make sure chains on the hydrophone cable are secure.
- Lower the rope drogue and end of the hydrophone cable over the stern and on the port side of the yellow umbilicals and the spreader rope (rope through stern chock) making sure the elements don't hit against the vessel.
- Feed out the hydrophone from the winch.
- Shut off winch controls, connect hydrophone cable to deck cable, turn on data processing unit.

Retrieval

- Make sure data processing unit is off.
- Make sure the deck cable is disconnected to the hydrophone cable.
- Retrieval is the opposite of deployment.
- Make sure the hydrophone elements don't hit against the stern and store them loosely around the winch.

HSE

All PPE required while on gun deck, including coveralls, hardhat, steel toe boots, safety glasses and gloves. Working close to the side, pinch points at the winch, trip hazards, and potential for jellyfish tentacles on the cable upon retrieval are potential hazards.

APPENDIX E: Summary of visual detections of protected species during the Cascadia thrust zone marine geophysical survey.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
1	4-Jul	12:30	Humpback whale	2	44.85303°N 124.22228°W	Full power	UN	SA DF	1767 m / Full power	Power down	Observed leaving 180 dB safety radius, resumed full power.
2	4-Jul	13:15	Humpback whale	2	44.86497°N 124.27708°W	Full power	PE/BH	SA DF	800 m / Not firing	Power / Shut down	Observed leaving 180 dB safety radius, initiated ramp-up.
3	4-Jul	14:14	Humpback whale	1	44.86537°N 124.32130°W	Full power	PE/AH	BV DF	1500 m / Mitigation	Power down	Observed leaving 180 dB safety radius, resumed full power.
4	4-Jul	15:01	Unidentified whale	1	44.86578°N 124.37902°W	Mitigation firing	UN	BV	5889 m / Full power	None	
5	4-Jul	15:55	Unidentified whale	2	44.83028°N 124.44088°W	Full power	PV/OD	BV	2614 m / Full power	None	
6	4-Jul	16:49	Unidentified whale	1	44.75025°N 124.47055°W	Full power	UN	BV	2200 m / Full power	None	
7	4-Jul	16:56	Unidentified whale	2	44.74123°N 124.47393°W	Full power	AV	BV	2200 m / Full power	None	
8	4-Jul	19:25	Unidentified baleen whale	2	44.51960°N 124.55597°W	Full power	PV/OD	BV DV	5664 m / Full power	None	
9	5-Jul	01:16	Unidentified whale	3	43.99905°N 124.74612°W	Full power	PV/OD	BV	5000 m / Full power	None	
10	5-Jul	02:14	Humpback whale	2	43.90757°N 124.77877°W	Full power	PV/OD	SA DF	1700 m / Full power	Power down	Observed leaving 180 dB safety radius, resumed full power.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
11	5-Jul	02:50	Unidentified whale	1	43.85925°N 124.79638°W	Full power	UN	BV	1702 m / Full power	Power down	Observed leaving 180 dB safety radius, resumed full power.
12	5-Jul	13:21	Humpback whale	1	44.46475°N 124.81943°W	Full power	AV	BV DF	3000 m / Full power	None	
13	5-Jul	13:21	Humpback whale	2	44.46475°N 124.81943°W	Full power	PE/AH	BV DF	2000 m / Full power	None	
14	5-Jul	13:54	Humpback whale	3	44.51697°N 124.79950°W	Full power	PV/OD	SA DF	300 m / Mitigation firing	Power down	Observed leaving 180 dB safety radius.
15	5-Jul	14:01	Humpback whale	2	44.51697°N 124.79950°W	Full power	AV	BV DF	1900 m / Full power	None	
16	5-Jul	14:16	Humpback whale	1	44.55143°N 124.78643°W	Mitigation firing	PV/SD	SA DF	200 m / Mitigation firing	None	Already powered down for Det. 14. Observed leaving 180 dB safety radius.
17	5-Jul	14:25	Unidentified whale	1	44.56328°N 124.78188°W	Mitigation firing	PV/OD	BV	5800 m / Mitigation firing	None	
18	5-Jul	16:28	Humpback whale	5	44.72555°N 124.71998°W	Full power	PV/OD	SA DF	350 m / Not firing	Power / Shut down	Using 160 dB safety radius for humpback whales.
19	6-Jul	2:17	Humpback whale	2	44.31482°N 124.27140°W	Full power	PV/OD	BV DV DF	4300 m / Mitigation firing	Power down	Using 160 dB safety radius for humpback whales.

APPENDIX F: Species of birds and other wildlife observed during the Cascadia thrust zone marine geophysical survey.

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Black-footed albatross	Diomedeidae	*Diomedea*	*nigripes*	**37**	**3**
Herring Gull	Laridae	*Larus*	*argentatus*	**39**	**3**
California Gull	Laridae	*Larus*	*california*	**1**	**1**
Common Murre	Alcidae	*Uria*	*aalge*	**21**	**3**
Northern Fulmar	Procellariidae	*Fulmarus*	*glacialis*	**1**	**1**
Unidentified petrel	Hydrobatidae	*Oceanodroma*		**3**	**2**
Unidentified shore bird				**3**	**1**

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Blue Shark	Carcharhinidae	*Prionace*	*glauca*	1	1
Unidentified moth				1	1
Dragon fly				1	1

APPENDIX G: Exceeded Take Reports

Time: 13:54 – 14:49 UTC, 16:28-17:55 UTC, 5 July 2012
Location: (44.51697°N, 124.79950°W) (44.72555°N, 124.71998°W)
Water depth: 350-404m
Vessel speed and heading: ~5 kts, 10°

Wind speed and direction: 10-12 kts North
Beaufort sea state: 3
Visibility: 10 km
Cloud cover/Glare: 30% / Moderate glare

Vessel activity at initial sighting: Firing full power on survey line
Source activity in 24 hours preceding sighting: Firing full power with the exception of four power downs for whales inside the safety radius.

Description of the incident: This report covers four separate sightings, three of them overlapping from 13:54-14:49 UTC. At 13:54 three humpback whales (two of them counting towards allotted takes) were observed off the bow of the vessel traveling parallel in the opposite direction. As they neared the 180 dB safety radius the acoustic source was powered down at 14:04. At 14:01 two more humpbacks were observed ~2 km off the port side of the vessel swimming away from the vessel. As the group of three continued to pass and were just off the stern of the vessel another humpback was observed breaching ~100 m off the bow of the vessel at 14:16. This whale fluked just off the stbd bow of the vessel and was next observed off the stern swimming parallel in the same direction. The original three whales were observed outside of the 180 dB safety radius at 14:23 and were last observed at 14:34 ~ 4 km from the vessel. The last whale was observed outside of the 180 dB safety radius ~2.6 km from the vessel at 14:49.

Another detection of five humpbacks occurred from 16:28-17:55 UTC. The whales were first observed ~2 km off the bow. As the vessel approached and they were identified as humpbacks the acoustic source was powered down. As the whales approached the 160 dB radius for the mitigation gun the acoustic source was shut down. The whales were last observed ~4.5 km from the vessel at 17:55 UTC and ramp-up was initiated at 18:25 UTC.

Description of all marine mammal observations in the 24 hours preceding the incident: Six humpback whale sightings. Seven unidentified whale sightings.

Photographs or video footage:n/a

Time: 2:17 – 3:26 UTC, 6 July 2012
Location: 44.31482°N, 124.27140°W
Water depth: 70m
Vessel speed and heading: 5.5 kts, 186°

Wind speed and direction: 11 kts North
Beaufort sea state: 3
Visibility: 10 km
Cloud cover/Glare: 35% / Severe glare

Vessel activity at initial sighting: Firing full power on survey line
Source activity in 24 hours preceding sighting: Firing full power with the exception of five power downs and one shut down for whales inside the safety radii.

Description of the incident: Two whales positively identified as humpbacks and the acoustic source powered down at 2:33 UTC. Whales remained farther than 4km from vessel and were last observed at 3:26 UTC. End of survey line was at 2:36 UTC completing the Trehu project.

Description of all marine mammal observations in the 24 hours preceding the incident: Ten humpback whale sightings. Eight unidentified whale sightings.

Photographs or video footage:n/a